OHIO STREAM-FLOW STUDY

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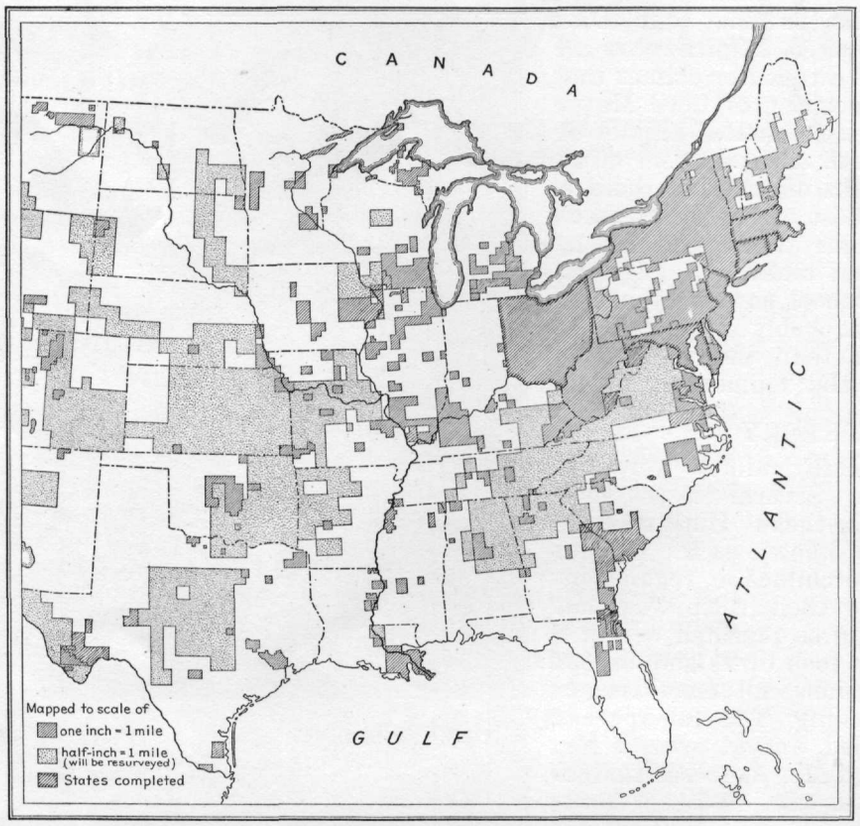


CONTOUR TOPOGRAPHIC SURVEYS TO JULY 1, 1921

THE foregoing map, showing the progress of the general utility map of the United States, shows that Ohio has beaten all states west of the Alleghenies in finishnig a complete Topographic Survey of its lands. In fact, no other state in the Union as large or larger, is done. The Ohio Legislature has more than made good in the case of Ohio land surveys.

But in the survey of its surface waters, Ohio is in the rear rank. This is shown by the table (next page), which gives State and Federal expenditures throughout the Union for measuring the flow of streams by the United States Geological Survey, which does practically all stream gaging in the country. As shown in the table, Ohio had expended only $1800 up to July 1, 1921, and this $1800 was expended prior to July 1, 1906, so that nothing was done for 15 years. Note the expenditures in other states.

Nevertheless a start was made in gaging Ohio rivers and their tributaries. The Eighty-fourth General Assembly appropriated $12,000 for the two years ending July 1st, 1923, to get the work going. To this amount the United States Geological Survey added $6000 cash, and furnished the necessary equipment for executing the work —the equivalent in all of supplying nearly $7000 of Government funds.

With the foregoing funds, two experienced hydraulic engineers have been sent by the Federal Government to Ohio; headquarters have been established at Columbus; numerous stream discharge measurements have been made over the state by these two engineers; 45 gages have been set on rivers at various points over the state; observers have been employed to read these gages daily; and the Federal engineers at Columbus are working up for publication the results of all the observations thus far taken.

This is good as far as it goes. But it does not go far enough! For example, Ohio has been using the more primitive staff and chain gages, while other states are using automatic self-recording gages at important or controlling points. As shown in Table B following, there is not a U. S. G. S. automatic self-recording gage on a single stream in Ohio:*

TABLE B

Water Stage Recorders Installed to July 1, 1922, in various U. S. G. S. Districts

Idaho	83
Hawaii	79
New York	28
Texas	24
Colorado-Wyoming	36
Illinois	1
Southeastern States	9
New Jersey	9
Oregon	55
Maryland	1
Virginia	2

Tennessee	4
Georgia	2
Alabama	3
Montana	28
Ohio	0
California	106
Washington	54
New England	30
Utah	34
Nevada	16
Arizona	7
Wisconsin	10
Iowa	6
Missouri	0
Kansas	14

*One has just been put on the Scioto by U. S. Weather Bureau.

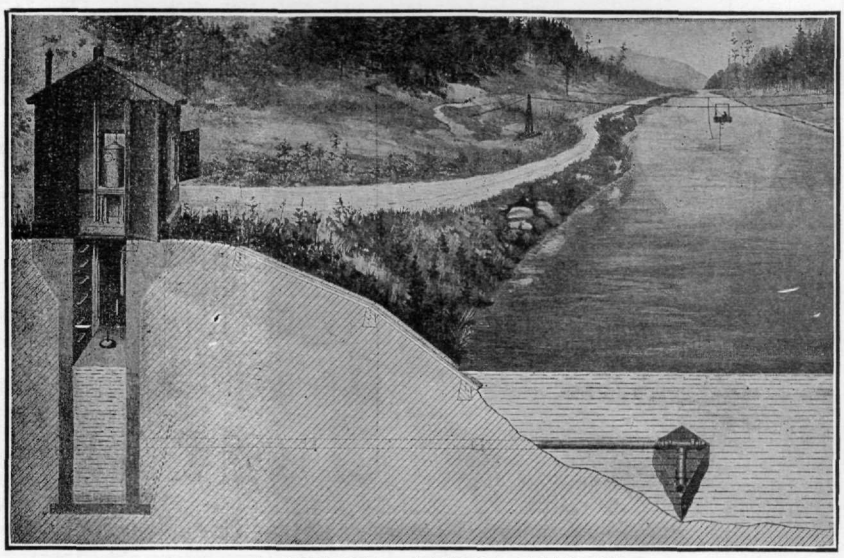
The difference between recording gages and others is that a recording gage registers **all stages of the water-surface day and night,** while with staff or chain gages only the elevation of the water-surface on the gage at the time of the observer's visit is noted. Thus the fluctuation of the river between gage readings is unknown in the case of staff or chain gages, which may be serious, if the **total amount of water flowing** is to be measured. **It is this total amount of water that is wanted,** not merely the daily heights on the gages.

To install staff and chain gages costs about $50 apiece, while to install **automatic self-recording gages** (or recorders, as they are called), costs about $1000 apiece. The difference in cost is due largely to the permanent housing

State Cooperation with U.S. Geological Survey in Water Resources Investigations and Federal Appropriations for Corresponding Periods.
to July 1, 1921.

State	Fiscal year 1910 & prior	Fiscal year 1911	Fiscal year 1912	Fiscal year 1913	Fiscal year 1914	Fiscal year 1915	Fiscal year 1916	Fiscal year 1917	Fiscal year 1918	Fiscal year 1919	Fiscal year 1920	Fiscal year 1921	Total
Alabama	$ 994	$ -----	$ -----	$ -----	$ -----	$ 170	$ 200	$ 175	$ 170	$ 205	$ 175	$ 110	$ 2,199
Arizona	-------	-------	-------	3,000	3,000	3900	3,960	4,040	2980	3,015	2985	3015	29,895
Arkansas	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
California	79487	9000	25000	28,586	16500	13200	16560	19495	18,620	20,865	26085	20970	294,368
Colorado	1,488	545	167	-------	-------	480	485	530	600	700	500	500	5,995
Connecticut	-------	-------	-------	1,000	1,000	1,000	1,555	770	-------	-------	1,005	365	6,695
Delaware	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Florida	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Georgia	-------	-------	-------	-------	-------	-------	-------	-------	-------	505	535	1300	2,340
Hawaii	-------	5,000	12,000	20000	15,000	15,400	20,090	16,000	19,080	19,000	26,200	29,080	196,850
Idaho	2,000	5,000	12,000	5,000	9,000	1,900	-------	-------	-------	1,310	11,155	12,505	55,870
Illinois	8676	3,000	2,191	-------	-------	3,400	2,355	2580	2675	2550	3620	4,000	35,047
Indiana	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Iowa	-------	-------	-------	-------	500	450	500	500	815	1695	2995	3,120	10,575
Kansas	413	-------	-------	-------	-------	-------	-------	1,000	2815	3250	4,010	5,910	17,398
Kentucky	-------	-------	-------	-------	-------	670	315	420	250	250	250	270	2,425
Louisiana	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Maine	37,505	1,000	1,350	-------	-------	75	4,515	5,640	3670	5000	4,290	4,435	67,480
Maryland	3,400	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	3,400
Massachusetts	1,050	825	1000	3,000	3,000	3,350	2,520	2370	2,025	3,240	2450	2,970	27,800
Michigan	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Minnesota	18,400	-------	16,000	3,650	3,500	2,100	2,400	2,470	-------	-------	610	465	49,595
Mississippi	-------	-------	-------	-------	-------	-------	-------	550	-------	-------	-------	-------	550
Missouri	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Montana	1,405	-------	3000	2,500	-------	2,500	2,875	2,760	1,720	2,205	3425	5530	27,920
Nebraska	1,700	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1,700
Nevada	1,250	-------	-------	385	2500	1800	3,140	1,980	2765	2085	2,510	2395	20,810
N. Hampshire	1,300	-------	-------	-------	-------	-------	-------	-------	1,060	2395	1,560	1,400	7,715
New Jersey	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
New Mexico	2,500	3,171	4,258	14,174	12,000	7,200	-------	-------	-------	-------	-------	-------	43,303
New York	21,374	11,090	13476	11,500	11,500	11,900	13,800	11,335	11,030	11,010	12,495	16,340	156,850
N. Carolina	576	-------	-------	-------	-------	-------	-------	-------	-------	280	415	2,315	3,586
N. Dakota	-------	-------	-------	-------	-------	350	500	300	385	600	575	270	2,980
Ohio ←	1,800	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	→ 1,800
Oklahoma	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Oregon	15,000	2,500	13,419	7,470	10,000	11,000	7,300	5700	6,935	5,735	5,700	7,225	97,984
Pennsylvania	2,188	-------	-------	-------	-------	-------	-------	-------	-------	-------	25780	19,420	47,388
Rhode Island	1,800	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1,800
S. Carolina	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
S. Dakota	-------	-------	-------	-------	-------	960	-------	-------	-------	180	180	45	1,365
Tennessee	-------	-------	718	-------	-------	-------	-------	-------	-------	660	490	1,305	3,173
Texas	-------	-------	-------	-------	-------	-------	8,500	10,295	10,965	9830	10,280	12,895	62,765
Utah	2,950	2,000	2,521	2,000	5,500	4,100	5,015	5,180	8,045	7,290	4,735	6,780	56,126
Vermont	1,000	1,000	1,000	1,000	1,200	900	1,440	1,245	1,065	1,330	1,060	1,270	13,510
Virginia	988	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	988
Washington	6,150	5,000	4,419	4,200	5,000	5,950	6,020	6,230	6,865	11,035	6,190	8,390	75,449
W. Virginia	-------	-------	-------	132	-------	400	-------	-------	-------	-------	355	590	1,477
Wisconsin	3,361	-------	-------	-------	8500	8800	6000	5970	5055	5,160	6,245	4,725	53,816
Wyoming	-------	-------	200	265	-------	1,600	5,010	4895	4450	4,815	4,520	5,505	31,260
Total	218,755	49,131	112,719	107,862	107,700	103,555	115,055	112,430	114,040	126,195	173,380	185,415	1,526,247
Federal Appropriations	1682,500	150,000	150,000	150,000	150,000	150,000	150,000	150,000	175,000	148,244	175,000	180,000	3,410,744

Grand Total ---------- 4,936,991.



A TYPICAL GAGING STATION

required for the recorders. But, as previously stated, recorders give a complete history of the fluctuations of a river (enabling accurate flowage calculations to be made) whereas staff and chain gages give always an incomplete history, enabling only approximate estimates of the flowage to be made.

Thus automatic recording gages are final, and do not need to have their records supplemented. Furthermore, being automatic, they are not subject to the mistakes a careless or neglectful observer may make. Also, being permanently situated, they remain the property of the state. Those states which started with staff or chain gages, only, are therefore changing to recording gages, at the controlling points of their rivers.

Ohio should do likewise. The Legislature, therefore, was asked to install 10 recording gages each year for eight years. These record-

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ers will be set at controlling points on rivers. Such locations of the 80 recorders, supplemented by 40 staff and chain gages (making 120 gages in all) will completely cover all important streams in the state and place Ohio abreast of other states in this important work.

Co-Operation With United States

The General Assembly, on April 27, 1923, appropriated $25,000 per year for two years. With the start thus made, if Ohio will continue at the same rate for the next few years it can overtake the other states in this important work, and by installing recorders in the beginning can avoid the inaccurate work that has been done in the earlier years in many of the other commonwealths. Ohio will profit by the experience in other states on account of employing the trained Federal engineers who have worked in other states.

This double saving (increased accuracy at less cost) happened in the topographic survey of Ohio lands. Some states started their maps on an inadequate scale, and are now remaking their maps. Ohio began later, but she began at once with adequate appropriations and a proper scale and overtook and passed her neighbors in completing her state land survey and map. Of the $650,000 expended on the contour topographic survey and map of Ohio, the National Government contributed nearly $300,000.

The United States will also co-operate in the water survey of Ohio by contributing money, special equipment and trained technical experts, who will be under the United States Civil Service just as they were on the topographic survey of the lands. The joint funds (State and National) will be expended equally in all parts of the state, because every stream basin of about 300 square miles in area will have its run-off measured.

The National Government will also publish all results at its own expense, as it has likewise published the topographic maps of the state at its own expense. A charge which covers the bare cost of publication is made for the maps, but the published water data will be furnished free. The vigorous prosecution of the Ohio Water Survey in co-operation with the United States is advisable from every viewpoint.

Why Should We Gage Our Streams?

Why measure the flow of our streams? Consider this: Not so long ago there was plenty of water in the rivers of Ohio and in other States. That was when the country was thinly populated, when the streams flowed more evenly—before the forests were cut down, and before farms were tiled and drained. Just as much rain falls now as then on the average, but it runs off quicker now, and we cannot stop the rush by pulling up the tile and re-foresting the land, because all cleared land is needed for farming in Ohio. The agricultural population of the State has not grown less, but the towns have grown larger so rapidly that there are now more people in town than in country (as shown by the 1920 census) making farm lands more needed than ever, to feed this increased urban population.

But this growth of population has brought greatly increased demand on the streams. Many new uses of water have been developed, all of which are essential. For example, prior to 1900, little was thought of irrigation in the United States. The great national irrigation works of the West (where the streams are regulated by storage) have all come into existence only in the last 20 years. Water is now stored for many purposes besides irrigation.

The use of streams for water power will increase. The increased cost of coal, and the apparently increasing labor troubles in mining coal from year to year indicate still greater and increasingly more efficient use of our streams for power in the future. Future hydro-electric plants will require that stream flow shall be carefully measured before such projects can be economically built. No power-house should be built on a stream without carefully calibrating its flow. Much money has been wasted by not determining the stream-flow carefully before building power-plants on some rivers.

Manufacturing plants now require large quantities of water for processes that did not exist 40 years ago and these processes are increasing, not diminishing, in number. The average person does not realize the extensive use of water in manufacturing. For example, the entire flow of the Mahoning River at Youngstown is at times run through the mills over and over again. Factories of all kinds will spring up over the State on streams where water is available. It is surprising to know that one of the difficulties of locating large steam plants for generating electric power in the coal fields, is to find water enough for boilers and condensers there.

Cities are making greater use than ever of streams for public water supplies. Groundwater proves inadequate as a town gets larger. One after another growing Ohio cities are abandoning ground-water supplies. The location of industries in these towns further accelerates the need for more water, until water famines already threaten some of the mid-State cities. These cities and others are therefore very much concerned as to just how much water will be available in the future not only for the purposes already mentioned, but for purposes of diluting their sewage. The proper dilution of sewage touches everyone who has an interest in restoring the purity of our rivers, so that they may be stocked with fish and used for recreation.

Likewise the farmer as well as the city dweller is interested in decreasing flood damages, because valleys are flooded in country as well as in town. Every one is touched by flood damage, whether he owns valley lands or not, because bridges and highways built by the public are destroyed in country as well as in town. In 1913 millions of dollars worth of public improvements were destroyed by flood through-

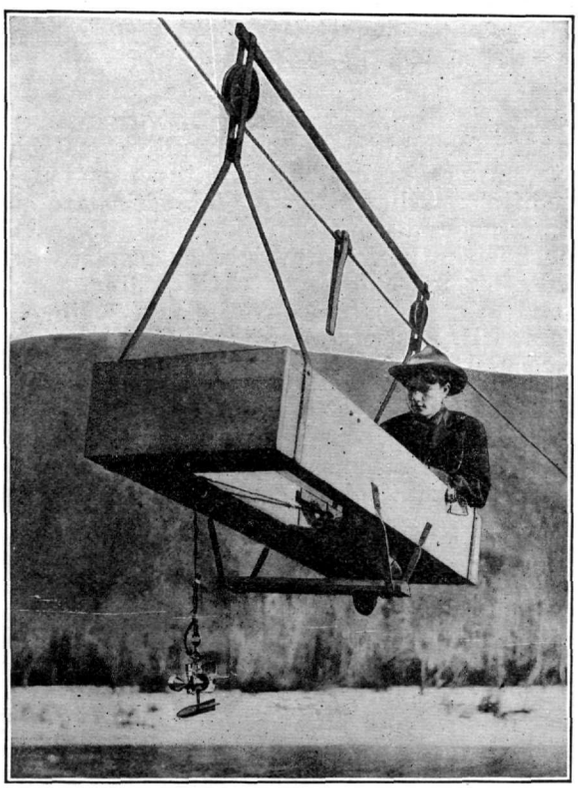
out the State, as shown on the State Highway Commissioners' Map accompanying.

To deal with all the foregoing problems and many others involving use of our streams, accurate data should be gathered with regard to their flow. It seems strange that while we have made careful studies of our coal, gas, oil, and other mineral resources, we have done next to nothing with our surface waters which promise in future to become one of the most important resources we have. Indeed, in some Western States, as suggested in table given, water is already the most important mineral resource, and is studied intensively for irrigation, water-power, and other purposes. New York, Pennsylvania and Illinois have long been engaged in extensive surveys of their water resources; the last named State through its Rivers and Lakes Commission, and New York and Pennsylvania through their Water Supply Commissions. Ohio is now well started and has now inaugurated one of the most vigorous studies of its water resources in the country.

Taking into consideration the establishment of automatic recorders; at the rate of 10 each year, from actual cost data secured from the District Engineer of the U. S. Geological Survey, Water Resources Branch, it is believed that a program looking to the establishment of 120 gaging stations (80 of them recorders) requiring a biennial appropriation of $66,000 by State and United States together will accomplish the above.

The details of this program are as follows:

Salaries of government employes	$ 9,600
Observers	6,000
Field Expenses	5,600
Construction	800
Top Cost	1,000
Total	$23,000
For two years	46,000
Ten Automatic Recorders per year for 2 years	20,000
Total for biennium	$66,000



TYPICAL GAGING CAR

All forward-looking citizens of Ohio are requested to urge this program of stream-flow work upon their members of Congress, because the project is clearly one for State and National co-operation and because no more important information concerning our natural resources is needed at this time. The general drouth prevailing over Ohio during the autumn of 1922. has brought a realization to many sections of the State for the first time, of the great and growing importance of water. **This situation is increasing, not diminishing in seriousness.** Help the State and National government solve it.